DOCUMENT RESUME

ED 268 442 CG 019 001

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TITLE Memory and Aging in a Cross Sectional Analysis.
PUB DATE [Nov 85]
NOTE 23p.; Paper presented at the Annual Scientific Meeting of the Gerontological Society (38th, New Orleans, LA, November 22-26, 1985).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Age Differences; *Aging (Individuals); *Cognitive Measurement; *Memory; *Sex Differences; *Test Validity; *Verbal Ability
IDENTIFIERS *Rey Auditory Verbal Learning Test

ABSTRACT

Although the accuracy of the diagnosis of cognitive impairment in the elderly depends on the appropriateness of the norms for the neuropsychological tests used, the importance of examining health status, native intelligence, and gender when attempting to describe cognitive changes of aging has received little attention. The Rey Auditory Verbal Learning Test (RAVLT) is one widely used instrument for assessing memory dysfunction. The effects of age, education, verbal intelligence, and gender on the RAVLT were investigated in 114 healthy volunteers between the ages of 40 and 84 years. Subjects completed the RAVLT as part of a comprehensive neuropsychological evaluation. The vocabulary subtest from the Wechsler Adult Intelligence Scale was also administered. The results revealed that, in the best fitting regression model, verbal intelligence and gender accounted for a significant proportion of the variance in performance on every learning trial of the RAVLT. Age was only related to performance on the first two trials and education was not related to performance. Higher verbal intelligence was associated with better performance, and women consistently performed better than men. These results suggest that many tests reported to demonstrate an aging effect may actually only be reflecting heterogeneity in verbal intelligence and gender differences in the population studied. (Author/NB)

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ED268442

MEMORY AND AGING IN A CROSS SECTIONAL ANALYSIS

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Running head: VARIABLES AFFECTING RAVLT

The effects of age, education, verbal intelligence and gender on the Rey Auditory Verbal Learning Test (RAVLT) was investigated. The RAVLT is a widely used instrument for assessing memory dysfunction. Healthy volunteers (N=114) between the ages of 40 - 84 years participated. In the best fitting regression model, verbal intelligence and gender acounted for a significant proportion of the variance in performance on every learning trial of the RAVLT. Age was only related to performance on trials I and II and education was not related to performance. Higher verbal intelligence was associated with better performance and women consistently performed better than men. These results suggest that many tests reported to demonstrate on aging effect may actually only be reflecting heterogeneity in verbal intelligence and gender differences in the populations studied. Therefore, research and clinical conclusions should be interpreted with caution in light of these results.

Researchers and clinicians alike have devoted a great deal of time and effort in trying to define "normal aging". Neuropsychological test performance is the method that is most frequently employed to differentiate normal cognitive changes with age from an early pathological condition such as Alzheimer's disease. The ability to discriminate subtle abnormalities from normal cognitive functioning in the elderly is a difficult and necessary task.

Accuracy of correct diagnoses of cognitive impairment in the elderly or any population depends on the appropriateness of the norms for each of the neuropsychological tests used. Those in aging research have come to appreciate the difficulty in determining what is "normal" for an elderly individual. Tests which have been used to define "aging effects" in a number of cognitive areas have been confounded by the heterogenity of the population studied. The importance of examining health status, native intelligence and gender when attempting to describe cognitive changes of aging has received minimal attention in the literature (Botwinick, 1983; Gade, Mortensen, Vaesen, Janssen & Udesen, 1985; Gade and Mortensen, in press)

In a study of normal aging in Denmark results showed that verbal intelligence played an important role in cognitive task performance over and above that explained by education. (Gade & Mortensen, in press) In a multiple regression analysis with both education and intelligence as variables, the correlation for

education turned insignificant, indicating that education may play its role through its correlation with the more powerful intelligence variable. These authors point out that studies which systematically investigate the role of verbal intelligence on cognitive task performance are virtually non-existent.

In the present study, we investigated the effects of age, education, verbal intelligence, and gender on the Rey Auditory Verbal Learning Test (RAVLT) which is a widely used clinical neuropsychological instrument for assessing memory dysfunction. Lezak (1983) has endorsed the use of the Rey Auditory Verbal Learning Task because of its ease of administration and because of the large amount of information it provides about various aspects of memory. In addition its differential sensitivity has been shown by Mungus (1983). Although Rey's original norms utilize broad age and occupation groups, essential information as to the educational level, verbal intelligence and gender are unknown. In an attempt to develop more adequate norms Query and Megrin (1983) published a report of age-related norms using 677 men, ranging in age from 19-81 years from a VA patient population. While these authors examined correlations between occupation, IQ and Rey Performance and found significant relationships which depended on the age group, this information was not incorporated into their 1983 norms. In addition, the use of only <u>inpatient males</u> severely limits the generalizability of these norms.

Since the Vocabulary subtest from the WAIS-R has been identified as the single best measure of both verbal and general ability (Lezak, 1983), and is the least affected by brain injury (Gonen & Brown, 1968) or aging (Botwinick, 1983) we chose this as our measure of verbal intelligence. It was hypothesized that individuals with higher verbal intelligence would perform better than individuals with lower verbal intelligence.

Previous investigations have reported better performance by females when compared to males on tasks of verbal learning (Ivison, 1977; Verhoff, Kaplan & Albert, 1979) and verbal memory, (Trahan, 1986; Larrabee, 1986). Therefore, we also expected to find better performance by women compared to men.

Methods

Subjects

Participants were 114 healthy volunteers, (55 men, 59 women) enrolled in the Johns Hopkins Teaching Nursing Home Study of Normal Aging. Subjects were included in the study if they had never had any of the following medical conditions: head trauma, stroke, seizure, uncontrolled hypertension, pulmonary edema, liver failure, renal failure, congestive heart failure, uncontrolled thyroid dysfunction, electroconvulsive therapy, sleep disorders, coma, psychiatric disorders, alcohol or drug abuse.

Procedure

The RAVLT was administered as part of a comprehensive neuropsychological evaluation. A word list consisting of 15 words was read aloud by the examiner at a rate of 1 per second. The participant was instructed to freely recall the list of words in any order. The entire list was read to the subject for five consecutive Learning Trials. Order of presentation of words remained fixed over trials. A Recognition Trial was given after the 5 learning trials, where the participant was instructed to identify (circle) as many words as possible that were just presented, from a list of 50 words. The number of words correctly recalled from each of the five learning trials and recognition trial were used for analysis.

In addition to the RAVLT, the Vocabulary Subtest from the Wechsler Adult Intelligence Scale (WAIS-R) was administered. The raw score was used for data analysis.

Results

The 114 participants ranged in age from 40 - 84 years. The range of education was 7 - 22 years, although the population was screwed in the more highly educated direction (median = 13.5 years). The socioeconomic status was middle to upper income. The number of participants in each age decade are presented in Table I.

Insert TABLE I about here

WAIS-R Vocabulary was not found to be affected by age (r = -.0157). This confirmed its utility as a stable measure of verbal intelligence. The relative contributions of age, education, verbal intelligence and gender on RAVLT performance were examined using a stepwise regression analysis on each of the five Learning Trials and Recognition Trial. The results of the regression analysis are presented in Table II.

Insert TABLE II about here

In the best fitting regression model, verbal intelligence and gender accounted for a significant proportion of the variance in performance on every learning trial of the RAVLT. Age accounted for a significant proportion of the variance on trials I and II, but was not significantly related to level of RAVLT performance on trials III, IV, V or Recognition. Education was not found to be significantly related to performance for any trial on the RAVLT once the contribution of verbal intelligence was partialed out.

Since a strong association was found between vocabulary and gender on RAVLT performance, men and women were examined separately and grouped by their WAIS-R Vocabulary Scores. A raw score of 50 fell at the lower quartile of our distribution and was therefore used to divide the groups. Table III presents the demographics of

the four groups. Significant differences were found for education and vocabulary but not age. Men and women in the low Vocabulary group (≤ 50) and the high Vocabulary group (> 50) had equivalent mean Vocabulary scores, respectively.

Insert TABLE III about here

Table IV summaries the mean scores on the five Learning Trials and Recognition Trial for the four groups.

Insert TABLE IV about here

Inspection of the means shows that higher verbal intelligence was associated with better RAVLT performance and women consistently performed better than men when equated for verbal intelligence. In fact, women with vocabulary scores ≤ 50 performed similarly to men with vocabulary scores > 50.

Group differences in RAVLT performance was further evaluated using a 2 x 2 (Vocabulary x Gender) Analysis of Variance. The results of this analysis are described in Table V. Signficant main effects of Vocabulary were found for all trials except Trial III. With the exception of Trial I significant effects for Gender were found for all Learning trials. No Vocabulary X Gender interaction was significant. Vocabulary and Gender main effects were absent for the Recognition portion of the RAVLT.

Insert TABLE V about here

Differences between the groups were isolated using the method outlined by Grantz (1981). Individual t-tests with Bonferroni corrections for multiple comparisons to examine specific comparisons are summarized in Table VI.

Insert TABLE VI about here

Men in the lower vocabulary group consistently performed below the other groups on RAVLT Learning Trials.

Discussion

In normal elderly individuals, overall performance on the Rey Auditory Verbal Learning Test is most strongly associated with verbal intelligence and gender but not age. These results show that individuals's with higher verbal intelligence perform better than those with lower verbal intelligence and women out perform men.

Age was found to negatively effect performance only on the initial two trials of the task. Since the RAVLT is a supraspan memory test (> 8 or 9 words) and Craik (1977) showed that the elderly show relative impairment on supraspan memory tasks, this finding is predictable. The reason for the elderly's difficulty on this type of memory task is believed to be due to differences

in speed of processing material and not due to defective learning capacity. Slower speed of processing by the elderly as compared to younger subjects has been well established (Kinsbourne & Berryhill, 1972; Schonfield & Wenger, 1975; Treat & Reese, 1976). Therefore, it is felt that our older participants performed below younger participants on the initial trials of the RAVLT because of slow speed of processing. These data also show that by the third trial, these same older individuals catch up and perform equivalent to the younger participants because repetition of the same material (practice) serves to overcome speed of processing deficits.

When Vocabulary score and level of Education were submitted simultaneously into the multiple regression analysis, Vocabulary was found to be significantly related to RAVLT performance while Education was unrelated. This finding supports Gade and Mortensen's (in press) finding that education plays a role in determining performance through its correlation with the more powerful verbal intelligence variable. Interpreting research and clinical findings with special consideration to verbal intelligence instead of educational level may be most critical for an elderly population. Higher levels of a formal education was the exception, rather than the rule in past eras, especially for women. This could result in little or no association between level of education and verbal intelligence which is indeed what we found in our women who scored above 50 on the Vocabulary test.

Higher verbal intelligence was associated with better performance than lower intelligence. Individuals with higher intellects probably obtain higher scores because they are able to employ more effective encoding strategies. Similarities and differences in recall strategies between the Vocabulary groups needs to be examined. If different strategies are found than it would be plausable to teach more effective encoding strategies which in turn should result in better performance.

Although sex differences have never been reported on the RAVLT, these results agree with those of others on similar verbal learning and memory tasks (Ivison, 1977; Veroff, et al., 1979; Trahan, 1986; and Larrabee, 1986). In addition, gender differences are not restricted to verbal learning and memory tasks. We have also found significant gender differences on simple visual reaction time. (Bleecker, Bolla-Wilson & Heller, 1985). A vast amount of literature is available on sex differences in the developmental literature (Maccaby & Jacklin, 1974) but this topic has been virtually ignored in the aging literature.

These results suggest that many standardized tests which have demonstrated aging effects may actually only be reflecting heterogeneity in the verbal intelligence and gender differences in the populations studied. For research purposes, before statements can be made about the effects of increasing age on

cognition, the role of other crucial variables need to be systematically investigated. From a clinical perspective, the ability to detect early cognitive impairments in an elderly individual directly depends on the appropriateness of the test norms. Therefore, tests such as the RAVLT need to be re-normed so separate norms for men and women with varying levels of verbal intelligence can be established. This data is currently being collected in our laboratory.

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Author Notes

Supported by NIA Teaching Nursing Home Award - 1PO1 AG0440301.

We acknowledge the assistance of JoEllen Heller, Peter Koeppl and Alan Remchuk in the data collection.

We also thank Jenny Finnesy and Rose Calini for preparation of this manuscript.

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TABLE I

PARTICIPANTS IN EACH AGE DECADE

DECADE	MEN	WOMEN
40 - 49	13	10
50 - 59	12	14
60 - 69	20	25
70 +	10	10
TOTAL	55	59

TABLE II

STEPWISE REGRESSION ON RAVLT

Trial	Step	Variable entered	p level	Increase in R^2	
I	1	Vocabulary	.01	.09	
	2	Age	.01	.06	.18 (total R^2)
	3	Sex	.05	.03	
II	1	Vocabulary	.01	.08	
	2	Sex	.05	.05	.17 (total R^2)
	3	Age	.05	.04	
III	1	Sex	.05	.05	
	2	Vocabulary	.05	.05	.10 (total R^2)
IV	1	Vocabulary	.01	.09	
	2	Sex	.01	.09	.18 (total R^2)
V	1	Vocabulary	.01	.12	
	2	Sex	.01	.05	.17 (total R^2)
Recognition	1	Vocabulary	.05	.03	.03 (total R^2)

TABLE III

DEMOGRAPHICS OF THE FOUR STUDY GROUPS

	MEN		WOMEN		
	Vocabulary		Vocabulary		
	≤50	>50	≤50	>50	F
N	16	39	16	43	
AGE	62 (10)	58 (12)	58 (12)	60 (10)	n.s.
EDUCATION (years)	12 (2)	15 (3)	12 (3)	14 (3)	**
VOCABULARY	46 (4)	59 (5)	42 (7)	59 (5)	**

** $p < .01$ MEAN (s.d.)

TABLE IV

PERFORMANCE MEANS AND STANDARD DEVIATIONS FOR

EACH GROUP ON THE REY AUDITORY VERBAL LEARNING TEST

		MEN		WOMEN	
		VOCABULARY		VOCABULARY	
N		16	39	16	43
Vocabulary		≤ 50	> 50	≤ 50	> 50
Trial					
I	Mean	5.6	6.6	5.9	7.1
	S.D.	(1.6)	(1.5)	(1.4)	(1.4)
II	Mean	7.7	9.5	9.3	9.9
	S.D.	(1.9)	(2.2)	(1.9)	(1.8)
III	Mean	9.6	10.6	11.2	11.4
	S.D.	(2.0)	(2.7)	(1.6)	(2.3)
IV	Mean	9.7	11.4	12.0	12.4
	S.D.	(2.7)	(2.5)	(1.8)	(2.1)
V	Mean	10.6	12.6	12.4	13.2
	S.D.	(2.2)	(2.2)	(2.0)	(2.1)
Recognition	Mean	13.6	14.3	14.5	14.3
	S.D.	(1.8)	(1.1)	(1.0)	(1.0)

TABLE V

F VALUES FOR THE VOCABULARY x GENDER ANALYSIS OF VARIANCE

Trial	Vocabulary	Gender
I	12.20**	1.87
II	8.22**	5.18*
III	1.58	5.67*
IV	5.02*	11.79**
V	8.80**	7.33**
Recognition	2.88	1.06

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d.f. (1,106)

* $p < .05$

** $p < .01$

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TABLE VI

SIGNIFICANT RESULTS FOR MULTIPLE T-TESTS

BETWEEN GROUPS ON THE RAVLT

Trials	Significant Group Comparisons	t-values
I	ML < WH**	-3.58
	WL < WH*	-2.73
II	ML < MH*	-2.91
	ML < WH**	-3.88
III	ML < WH*	-2.86
IV	ML < MH*	-2.73
	ML < WL*	-2.99
	ML < WH***	-4.26
V	ML < MH**	-3.47
	ML < WL*	-2.71
	ML < WH***	-4.46

ML - Men - Vocabulary < 50
MH - Men - Vocabulary > 50
WL - Women - Vocabulary < 50
WH - Women - Vocabulary > 50

Using Bonferreni correction for multiple comparisons

d.f. = (110)

* p < .05

** p < .01

*** p < .001